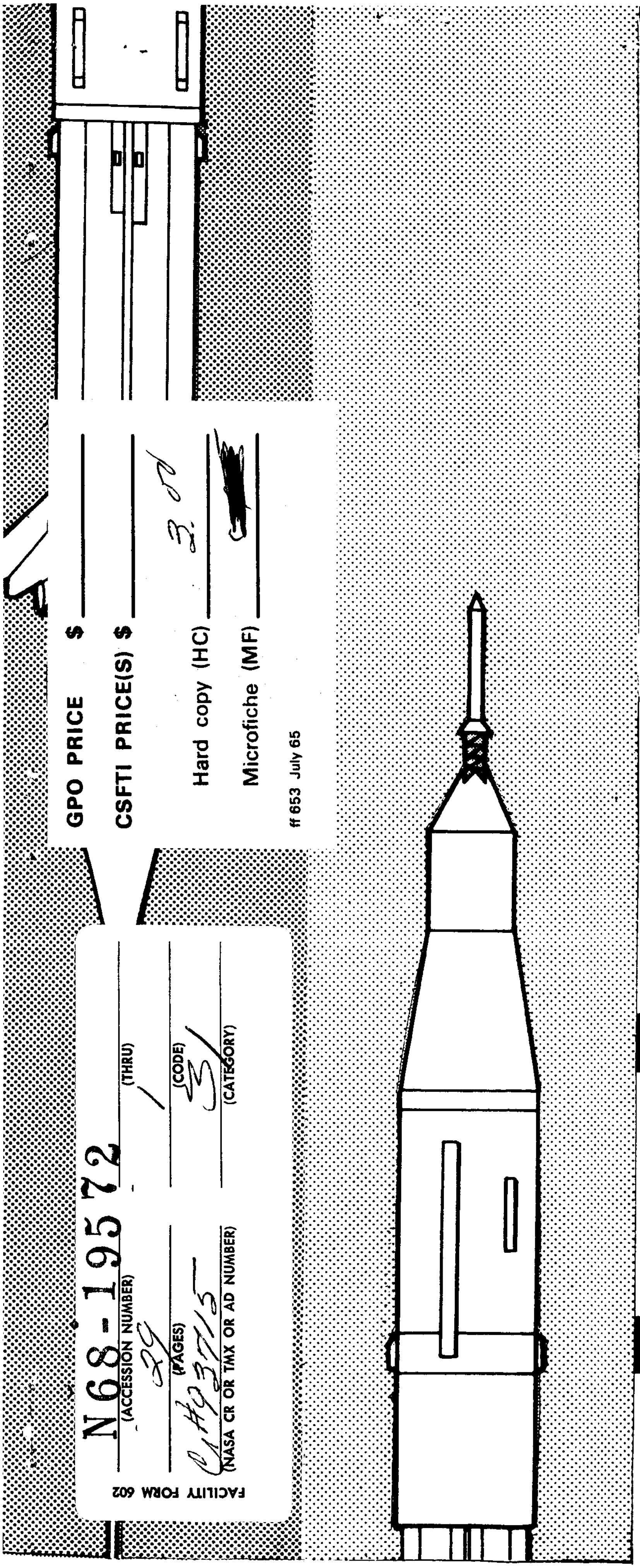

H.T.

SSR-105
(TN-AP-67-258)

AAP PRELIMINARY RANGE SAFETY ANALYSIS

CONTRACT NAS8-4016
SCHEDULE II, VEHICLE SYSTEMS INTEGRATION

SPACE DIVISION CHRYSLER CORPORATION

Ag 15848 8

SSR-105
(TN-AP-67-258)

AAP PRELIMINARY RANGE SAFETY ANALYSIS

JULY 1967

By

AEROSPACE PHYSICS BRANCH
CHRYSLER CORPORATION SPACE DIVISION

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PREFACE

This technical note presents data and results of a preliminary range safety analysis applicable to the Saturn IB Nose Cone and CSM configurations. The analysis documented herein has been scoped to meet the requirements of the range control office and was accomplished under MSFC SSR Number 105 issued 19 June 1967, and entitled "AAP Preliminary Range Safety Study". The scheduled delivery date for the document and cape magnetic tape is 20 July 1967.

SUMMARY

This document presents range safety data and results for a Saturn IB/CSM configuration into an 81 x 120 n. mi. elliptical orbit and for a Saturn IB/NC configuration into a 260 n. mi. circular orbit. Orbit inclination is 50 deg with flight azimuths of 39.8 deg and 110 deg for both configurations.

The S-IB stage in-plane impact containment zones, for the nose cone configuration north and southeast launches, are 31 km and 37 km long, respectively. Similiar data for the CSM configuration are 46 km and 50 km, while the applicable CSM S-IVB stage impact zones are 201 km for the north launch and 168 km for the southeast launch.

Since land masses are overflown, an impact and casualty probability study is conducted. A summary of these data as well as a comparison with the standard manned Apollo 72 deg flight azimuth are presented below:

	Dwell Time sec		Probability of Land Impact	Probability of Casualty
Manned Apollo 72deg azimuth		8.5	5.5×10^{-4}	2.0×10^{-5}
North Launch 39.8 deg azimuth	NC	25	1.6×10^{-3}	1.7×10^{-4}
	CSM	74	1.2×10^{-2}	4.7×10^{-4}
Southeast Launch 110 deg azimuth	NC	28	1.5×10^{-3}	4.1×10^{-5}
	CSM	102	1.5×10^{-2}	1.5×10^{-4}

Previous studies indicate the optimum Service Module propellant required is from 15,000 to 16,000 lbs. These studies also showed that payload variations are insensitive to large changes in SM propellant burned. However, a cursory examination of resulting impact data shows the amount of SM propellant can have a significant effect on IIP range. This effect, although not part of SSR-105, should be considered in future CSM vehicle performance and range safety studies.

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Section 1.0 - INTRODUCTION

MSFC issued SSR No. 105 as a follow-up to the payload and mission capability feasibility study performed under MCRR No. 102 on 1 June 1967. The purpose of this SSR is to determine Saturn IB in-plane flight corridors for selected north and southeast launches for 50 degree orbital inclinations in order that the Range may assess the hazards involved in such flights. This report and the data compiled on an associated cape magnetic tape documents the work done to satisfy SSR 105.

A description of the study requirements delineated in the SSR follows.

A. Use a Saturn IB/CSM "2½ stage" configuration for insertion into a 81 x 120 n. mi. orbit, and a Saturn IB/Nose-Cone configuration for insertion into a 260 n. mi. circular orbit.

B. Generate a nominal, a 3σ maximum, and a 3σ minimum trajectory for each configuration at each launch azimuth.

C. Prepare the data in report form and on a cape magnetic tape, in the proper format as specified by the range office.

Contained herein are the expected $\pm 3\sigma$ in-plane trajectory deviations from the intended flight path; expected impact of the S-IB and S-IVB stages; and downrange land impact and casualty probabilities for both configurations. The cape magnetic tape associated with this analysis is CCSD Reel No. 0061 .

Section 2.0 - NOSE CONE CONFIGURATION

Formal range safety data requirements are defined for the launch agency by the Deputy Commander of tests (Reference 1). The following sections present the required trajectory data associated with the nose cone standard and in-plane dispersed trajectories.

2.1 Standard Trajectories

The standard trajectories for the nose cone configuration missions are similiar to selected trajectories documented in the feasibility study of Reference 2. Figure 1 shows an outboard profile of the nose cone configuration, Table 1 presents the sequence of events, while Figures 4 and 5 illustrate the altitude-range profile and IIP traces. The range safety required data are contained on the cape magnetic tape in Record 12, Files 2 and 5.

2.2 Dispersed Trajectories

Listed below are the combined off nominal parameter variations about the respective nose cone standard trajectories which define the in-plane dispersed trajectories. Figure 3 illustrates the annual wind profile envelopes, applicable to this study, as documented in Reference 3.

3σ Maximum North	S-IB Stage:	+ 1.7% Thrust and Flow Rate, TWN.
	S-IVB Stage:	+ 3.0% Thrust and Flow Rate, TWN.
3σ Minimum North	S-IB Stage:	-2.6% Thrust and Flow Rate, HWN.
	S-IVB Stage:	- 3.0% Thrust and Flow Rate, HWN.
3σ Maximum Southeast	S-IB Stage:	+ 1.7% Thrust and Flow Rate, TWE.
	S-IVB Stage:	+ 3.0% Thrust and Flow Rate, TWE.
3σ Minimum Southeast	S-IB Stage:	- 2.6% Thrust and Flow Rate, HWE.
	S-IVB Stage:	- 3.0% Thrust and Flow Rate, HWE.

The range safety data requirements prescribed by the range control office, in connection with the above trajectories, are contained in Record 12, Files 3, 4, 6, and 7 on the cape magnetic tape at one second time intervals.

2.3 Stage Impacts

Impact data for the S-IB stage for both the standard and perturbed trajectories are presented in the following table and are illustrated in Figure 6. These data reflect atmospheric re-entry and retro-rocket firing.

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
Standard North	32.2489	77.0226	488.2	535.1	288.9
3 σ Maximum North	32.3720	76.8936	494.6	553.3	298.8
3 σ Minimum North	32.1645	77.1095	477.6	522.6	282.2
Standard Southeast	26.4070	75.0387	477.1	594.0	320.7
3 σ Maximum Southeast	26.3319	74.8443	483.7	615.1	332.1
3 σ Minimum Southeast	26.4633	75.1767	465.9	578.8	312.5

2.4 3 σ Flight Corridor

The pitch plane corridor limits for the nose cone configuration are defined by the respective 3 σ maximum flight profile and the 3 σ minimum flight profile.

At S-IB/S-IVB stage separation, for the north launch, the 3 σ maximum flight profile produces an increase from that of the standard in inertial velocity and altitude of 30 m/sec and 505 m, respectively. The 3 σ minimum north launch vehicle profile produces a decrease, relative to the standard , in inertial velocity of 27 m/sec and in altitude of 1355 m. Corresponding data applicable to the southeast launch are 30 m/sec and 507 m for the 3 σ maximum profile and 23 m/sec and 1499 m related to the 3 σ minimum flight profile.

S-IVB stage guidance target conditions: inertial velocity (V), radius (R), flight path angle (γ), inclination angle (i), and argument of descending node (θ_n) for a $\pm$ 3 σ vehicle profile are virtually unchanged from those of the standard. For normal operation, the north launch S-IVB stage guidance cutoff signal is predicted to occur at 596.008 $\pm$ 22 sec following first motion, at a downrange distance from the launch site of 1540 $\pm$ 49 km. Similiar data for the southeast launch are 596.009 $\pm$ 19 sec and 1600 $\pm$ 42 km.

For the north launch, the 3 σ maximum profile increases the downrange impact of the standard trajectory S-IB stage by 19 km, while the 3 σ minimum flight profile causes the S-IB stage to impact 13 km short of the standard impact point. Similiar southeast launch related data are 22 km for the 3 σ maximum profile and 16 km for the 3 σ minimum profile.

The 3 σ maximum north launch trajectory IIP reaches the downrange land mass of Eurasia at approximately 546 sec after lift off, while the 3 σ minimum north launch trajectory IIP leaves the above land mass at approximately 610 sec of flight. For the southeast launch the 3 σ maximum trajectory IIP reaches the downrange land mass of South America at approximately 519 sec after lift off, and the 3 σ minimum trajectory IIP departs from this land mass at approximately 571 sec.

Figure 4 presents altitude versus range for the $\pm$ 3 σ pitch plane flight profile associated with the north launch. These data are deemed applicable to the southeast launch.

2.5 Downrange Impact and Casualty Probability

Illustrated in Figures 5 through 8 are pertinent range safety data, such as, instantaneous impact point traces, stage impacts, crossrange impact corridors, etc. associated with the various trajectory profiles considered in this study. The lateral impact corridors are approximately $\pm$ 100 km.

The probability of a malfunctioning vehicle impacting on land is calculated as:

S-IB Stage Flight

$$P_I = P(F)_1 \cdot P(F)_x \cdot P(F)_y$$

S-IVB Stage Flight

$$P_I = P(S)_1 \cdot P(F)_2 \cdot P(F)_x \cdot P(F)_y$$

Service Module Powered Flight

$$P_I = P(S)_1 \cdot P(S)_2 \cdot P(F)_3 \cdot P(F)_x \cdot P(F)_y$$

where:
$P(S)_1$ = Probability of successful first stage operation.
$P(S)_2$ = Probability of successful second stage operation.
$P(F)_1$ = Probability of first stage failure.
$P(F)_2$ = Probability of second stage failure.
$P(F)_3$ = Probability of third stage failure.
$P(F)_x$ = Probability of failure in the downrange (x) direction.
$P(F)_y$ = Probability of failure in the crossrange (y) direction

The probability of injuring a person downrange is calculated as:

$$P_{IP} = P_I \cdot \frac{N}{A} \cdot L_A$$

where: P_I = Probability of impact

$\frac{N}{A}$ = Population density

L_A = Lethal area of impacting vehicle:
S-IB Stage powered flight - 37,744 sq. ft.
S-IVB Stage powered flight - 19,400 sq. ft.
Service Module powered flight- 7,600 sq. ft.

<u>Nose Cone Config. North Launch</u>

The probability of impact within the range safety 3 σ lateral corridor for Eurasia is:

$$P_{I_{EU}} = .957 \cdot .030 \cdot \frac{24.70}{449.04} \cdot 1 = 1.58 \times 10^{-3}$$

The probability of impact for individual countries within the 3 σ lateral corridor is:

COUNTRY	Δt	P_I
Great Britain	0.50	1.60×10^{-6}
France	8.50	5.43×10^{-4}
Switzerland	1.50	6.71×10^{-5}
Italy	4.00	2.56×10^{-4}
Yugoslavia	1.90	4.86×10^{-5}
Albania	0.80	5.11×10^{-5}
Greece	1.60	1.02×10^{-4}
Turkey	1.40	4.48×10^{-5}
Israel	0.50	3.20×10^{-5}
Jordan	0.65	4.16×10^{-5}
United Arab Rep. (Egypt)	0.25	6.39×10^{-6}
Saudi Arabia	2.90	1.85×10^{-4}
Hadhramaut	0.30	1.92×10^{-5}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Eurasia is:

$$P_{IP_{EU}} = 1.58 \times 10^{-3} \cdot 150 \cdot \frac{19,400}{27,878,400} = 1.65 \times 10^{-4}$$

The probability of injuring a person for individual countries within the 3 σ lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Great Britain	190	2.11×10^{-7}
France	175	6.62×10^{-5}
Switzerland	250	1.17×10^{-5}
Italy	410	7.30×10^{-5}
Yugoslavia	95	3.21×10^{-6}
Albania	75	2.67×10^{-6}
Greece	95	6.76×10^{-6}
Turkey	120	3.74×10^{-6}
Israel	95	2.11×10^{-6}
Jordan	25	7.23×10^{-7}
United Arab Rep. (Egypt)	65	2.89×10^{-7}
Saudi Arabia	2	2.58×10^{-7}
Hadhramaut	10	1.33×10^{-7}

<u>Nose Cone Config. Southeast Launch</u>

The probability of impact within the range safety 3σ lateral corridor for South America is:

$$P_{I_{SA}} = .957 \cdot .03 \cdot \frac{19.0}{453.74} \cdot 1 = 1.41 \times 10^{-3}$$

The probability of impact for individual countries within the 3σ lateral corridor is:

COUNTRY	Δt	P_I
Great Abaco (Is.)	9.0	1.15×10^{-4}
Brazil	19.0	1.41×10^{-3}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for South America is:

$$P_{IP_{SA}} = 1.41 \times 10^{-3} \cdot 35 \cdot \frac{19,400}{27,878,400} = 3.43 \times 10^{-5}$$

The probability of injuring a person for individual countries within the lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Great Abaco (Is.)	40	6.23×10^{-6}
Brazil	35	3.43×10^{-5}

Section 3.0 - CSM CONFIGURATION

The following sections present the required trajectory data associated with the CSM standard and in-plane dispersed trajectories.

3.1 Standard Trajectories

The standard trajectories for the CSM configuration missions are similiar to selected trajectories documented in Reference 2. Figure 2 shows an outboard profile of the CSM configuration, Table 1 presents the time sequence of events, while Figures 4 and 5 illustrate the altitude-range profile and IIP traces. The range safety required data are contained on the cape magnetic tape in Record 12, Files 8 and 11.

3.2 Dispersed Trajectories

Listed below are the combined off nominal parameter variations about the respective CSM standard trajectories which define the in-plane dispersed trajectories. Figure 3 illustrates the annual wind profile envelopes, applicable to this study, as documented in Reference 3.

3 σ Maximum North	S-IB Stage:	+1.7% Thrust and Flow Rate, TWN.
	S-IVB Stage:	+3.0% Thrust and Flow Rate, TWN.
	SM Stage:	+3.0% Thrust and Flow Rate, TWN.
3 σ Minimum North	S-IB Stage:	-2.6% Thrust and Flow Rate, HWN.
	S-IVB Stage:	-3.0% Thrust and Flow Rate, HWN.
	SM Stage:	-3.0% Thrust and Flow Rate, HWN.
3 σ Maximum Southeast	S-IB Stage:	+1.7% Thrust and Flow Rate, TWE.
	S-IVB Stage:	+3.0% Thrust and Flow Rate, TWE.
	SM Stage:	+3.0% Thrust and Flow Rate, TWE.
3 σ Minimum Southeast	S-IB Stage:	-2.6% Thrust and Flow Rate, HWE.
	S-IVB Stage:	-3.0% Thrust and Flow Rate, HWE.
	SM Stage:	-3.0% Thrust and Flow Rate, HWE.

The range safety data requirements prescribed by the range control office, in connection with the above trajectories, are contained in

Record 12, Files 9, 10, 12 and 13 on the cape magnetic tape at one second time intervals.

3.3 Stage Impacts

Impact data for the S-IB and S-IVB Stages for both the standard and perturbed trajectories are presented below and are illustrated in Figures 5 and 6. These data reflect atmospheric re-entry and S-IB stage retro-rocket firing where applicable.

S-IB Stage Impact

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
Standard North	31.6958	77.5090	381.9	458.6	247.6
3 σ Maximum North	31.8470	77.3542	388.9	480.8	259.6
3 σ Minimum North	31.5352	77.6721	369.8	435.0	234.9
Standard Southeast	26.9551	76.3162	375.4	453.1	244.7
3 σ Maximum Southeast	26.8709	76.0919	382.4	477.2	257.7
3 σ Minimum Southeast	27.0478	76.5551	362.9	427.2	230.7

S-IVB Stage Impact

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
Standard North	48.8899	38.4109	623.6	4230.3	2284.2
3 σ Maximum North	49.0402	37.5578	632.3	4294.9	2319.1
3 σ Minimum North	48.5890	40.2088	607.8	4094.0	2210.6
Standard Southeast	4.6318	50.7989	605.2	4107.6	2217.9
3 σ Maximum Southeast	4.3728	50.3570	614.5	4162.9	2247.8
3 σ Minimum Southeast	5.2708	51.5950	590.3	3995.0	2157.1

3.4 3 σ Flight Corridor

The pitch plane corridor limits for the CSM configuration are defined by the respective 3 σ maximum and the 3 σ minimum flight profile.

At S-IB/S-IVB stage separation, for the north launch, the 3 σ maximum flight profile produces an increase from that of the standard in inertial velocity and altitude of 27 m/sec and 897 m, respectively. The 3 σ minimum north launch vehicle profile produces a decrease, relative to the standard, in inertial velocity of 19 m/sec and in altitude of 2053 m. Corresponding data applicable to the southeast launch are 28 m/sec and 861 m for the 3 σ maximum profile and 18 m/sec and 2118 m related to the 3 σ minimum flight profile.

At S-IVB/SM stage separation, for the north launch, the 3 σ maximum flight profile corridor produces an increase from that of the standard in inertial velocity and altitude of 110 m/sec and 4,990 m, respectively. The 3 σ minimum north launch vehicle profile produces a decrease, relative to the standard, in inertial velocity of 191 m/sec and in altitude of 10,670 m. Corresponding data applicable to the southeast launch are 70 m/sec and 1075 m for the 3 σ maximum profile and 136 m/sec and 2307 m related to the 3 σ minimum flight profile.

SM stage guidance target conditions: inertial velocity (V), radius (R), flight path angle (γ), inclination angle (i), and argument of descending node (θ_n) for a $\pm$ 3 σ vehicle profile are virtually unchanged from those of the standard. For normal operation the SM stage guidance cutoff signal for the north launch is predicted to occur at 831.93 $\pm$ 71 sec following first motion, at a downrange distance from the launch site of 3294 $\pm$ 356 km. Similiar data for the southeast launch are 832.05 $\pm$ 51 second 3295 $\pm$ 232 km.

For the north launch, the 3 σ maximum profile increases the downrange impact of the standard trajectory S-IB stage by 23 km, while the 3 σ minimum flight profile causes the S-IB stage to impact 24 km short of the standard impact point. Similiar southeast launch related data are 25 km for the 3 σ maximum profile and 26 km for the 3 σ minimum profile.

Downrange impact of the S-IVB stage 3 σ maximum profile north launch is increased from the standard trajectory data by 65 km, while the 3 σ minimum flight profile causes the S-IVB stage to impact 137 km short of the standard impact point. Corresponding data related to the southeast launch are 56 km for the 3 σ maximum profile and 113 km for the 3 σ minimum profile

The 3 σ maximum north launch trajectory IIP reaches the downrange land mass of Eurasia at approximately 700 sec after lift off, while the 3 σ minimum north launch trajectory IIP leaves the above land mass at approximately 880 sec of flight. For the southeast launch the 3 σ maximum trajectory IIP reaches the downrange land mass of South America at approximately 613 sec after lift off, and the 3 σ minimum trajectory IIP departs from this land mass at approximately 773 sec.

Figure 4 presents altitude versus range for the $\pm$ 3 σ pitch plane flight profile associated with the north launch. These data are deemed applicable to the southeast launch.

3.5 Downrange Impact and Casualty Probability

General information pertaining to this section was previously presented in Section 2.5. Previous studies indicate the optimum Service Module propellant required is from 15,000 to 16,000 lbs. These studies also showed that payload variations are insensitive to large changes in SM propellant burned. However, a cursory examination of resulting impact data shows the amount of SM propellant can have a significant effect on IIP range. This effect, although not part of SSR-105, should be considered in future CSM vehicle performance and range safety studies.

CSM Configuration North Launch

The probability of impact within the range safety 3 σ lateral corridor for Eurasia is:

$$P_{I_{EU}} = .957 \cdot .970 \cdot .04 \cdot \frac{73.70}{236.04} \cdot 1 = 1.16 \times 10^{-2}$$

The probability of impact for individual countries within the 3 σ lateral corridor is:

COUNTRY	Δt	P_I
Great Britain	2.20	1.73×10^{-5}
France	25.50	4.01×10^{-3}
Switzerland	6.00	5.66×10^{-4}
Italy	12.00	1.89×10^{-3}
Yugoslavia	4.20	1.98×10^{-4}
Albania	2.90	4.56×10^{-4}
Greece	4.50	7.08×10^{-4}
Turkey	3.70	2.91×10^{-4}
Israel	1.00	1.57×10^{-4}
Jordan	1.90	2.99×10^{-4}
United Arab Rep.(Egypt)	0.60	3.78×10^{-5}
Saudi Arabia	7.60	1.20×10^{-3}
Hadhramaut	0.70	1.10×10^{-4}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Eurasia is:

$$P_{IP_{EU}} = 1.16 \times 10^{-2} \cdot 150 \cdot \frac{7600}{27,878,400} = 4.74 \times 10^{-4}$$

The probability of injuring a person for individual countries within the 3 σ lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Great Britain	190	8.96×10^{-7}
France	175	1.91×10^{-4}
Switzerland	250	3.86×10^{-5}
Italy	410	2.11×10^{-4}
Yugoslavia	95	5.13×10^{-6}
Albania	75	9.33×10^{-6}
Greece	95	1.83×10^{-5}
Turkey	120	9.52×10^{-6}
Israel	95	4.07×10^{-6}
Jordan	25	2.04×10^{-6}
United Arab Rep. (Egypt)	65	6.69×10^{-7}
Saudi Arabia	2	6.52×10^{-7}
Hadhramaut	10	3.00×10^{-7}

CSM Config. Southeast Launch

The probability of impact within the range safety 3 σ lateral corridor for South America is:

$$P_{I_{SA}} \quad .957 \cdot .970 \cdot .04 \cdot \frac{92.0}{236.03} \cdot 1 = 1.45 \times 10^{-2}$$

The probability of impact for individual countries within the 3 σ lateral corridor is:

COUNTRY	Δt	P_I
Great Abaco (Is.)	10.0	1.28×10^{-4}
Brazil	92.0	1.45×10^{-2}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for South America is:

$$P_{IP_{SA}} = 1.45 \times 10^{-2} \cdot 35 \cdot \frac{7600}{27{,}878{,}400} = 1.38 \times 10^{-4}$$

The probability of injuring a person for individual countries within the lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Great Abaco (Is.)	40	6.93×10^{-6}
Brazil	35	1.38×10^{-4}

Section 4.0 - REFERENCES

1) AFETRM 127-1, Safety Range Safety Manual, dated 1 November 1966.

2) CCSD TN-AP-67-243, AAP-2 Through 4 Payload and Mission Capability Increase Feasibility Study For Specified Cases, dated 1 June 1967.

3) MSFC R-AERO-Y-118-66, Cape Kennedy Wind Component Statistics, 0-60 km Altitude, for All Flight Azimuths for Monthly and Annual Reference Period, dated October 25, 1966.

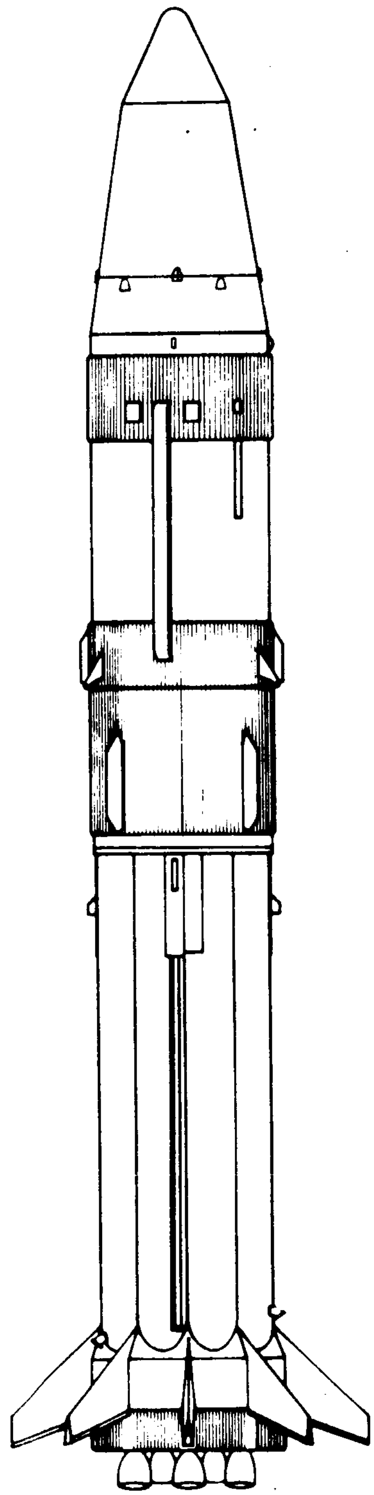
Section 5.0 - DISTRIBUTION

W.H. Mann, Jr.	I-1/1B-E	(1)
L.M. McNair	R-AERO-P	(56 copies, 1 reproducible and 1 magnetic tape)

TABLE 1

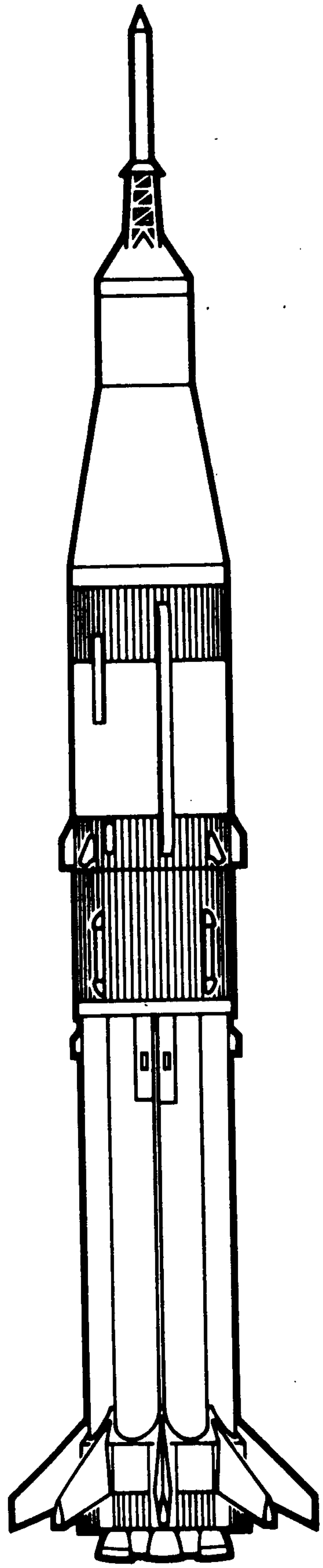
NOSE CONE AND CSM CONFIGURATIONS
SEQUENCE OF EVENTS

Event	Time In Seconds NC Config.	CSM Config.
Lift-Off	0.000	0.000
Initiate Pitch Maneuver	10.000	10.000
Tilt Arrest	130.970	130.970
Inboard Engine Cutoff (IECO)	137.970	137.970
Outboard Engine Cutoff (OECO)	140.970	140.970
Separation	142.270	142.270
J-2 Engine Start	146.970	146.970
EMR Stepup	148.270	148.270
Jettison Ullage Rocket Cases	156.970	156.970
Jettison LES	———	176.520
Initiate IGM	156.970	176.520
EMR Stepdown	426.970	426.970
J-2 Engine Cutoff (39.8 DEG AZ)	596.008	596.025
J-2 Engine Cutoff (110 DEG AZ)	596.009	596.025
SM Engine Start	———	596.025
SM Engine Cutoff (39.8 DEG AZ)	———	831.930
Time of Epoch (39.8 DEG AZ)	606.008	841.930
SM Engine Cutoff (110 DEG AZ)	———	832.051
Time of Epoch (110 DEG AZ)	606.009	842.051



NOSE CONE CONFIGURATION

FIG. 1



CSM CONFIGURATION

Fig. 2

ANNUAL WIND PROFILE ENVELOPES

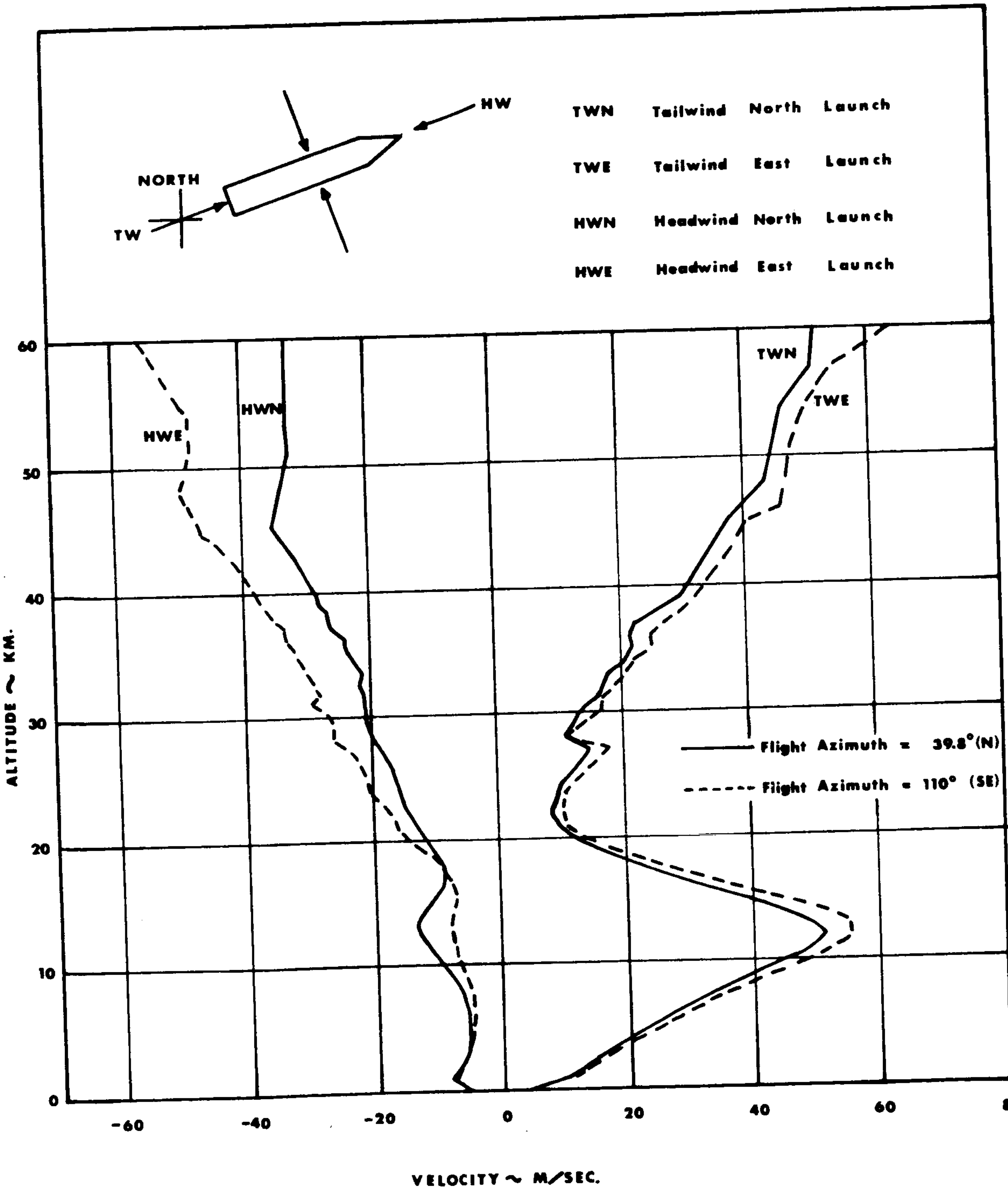


Fig. 3

PITCH PLANE FLIGHT PROFILE – NORTH LAUNCH

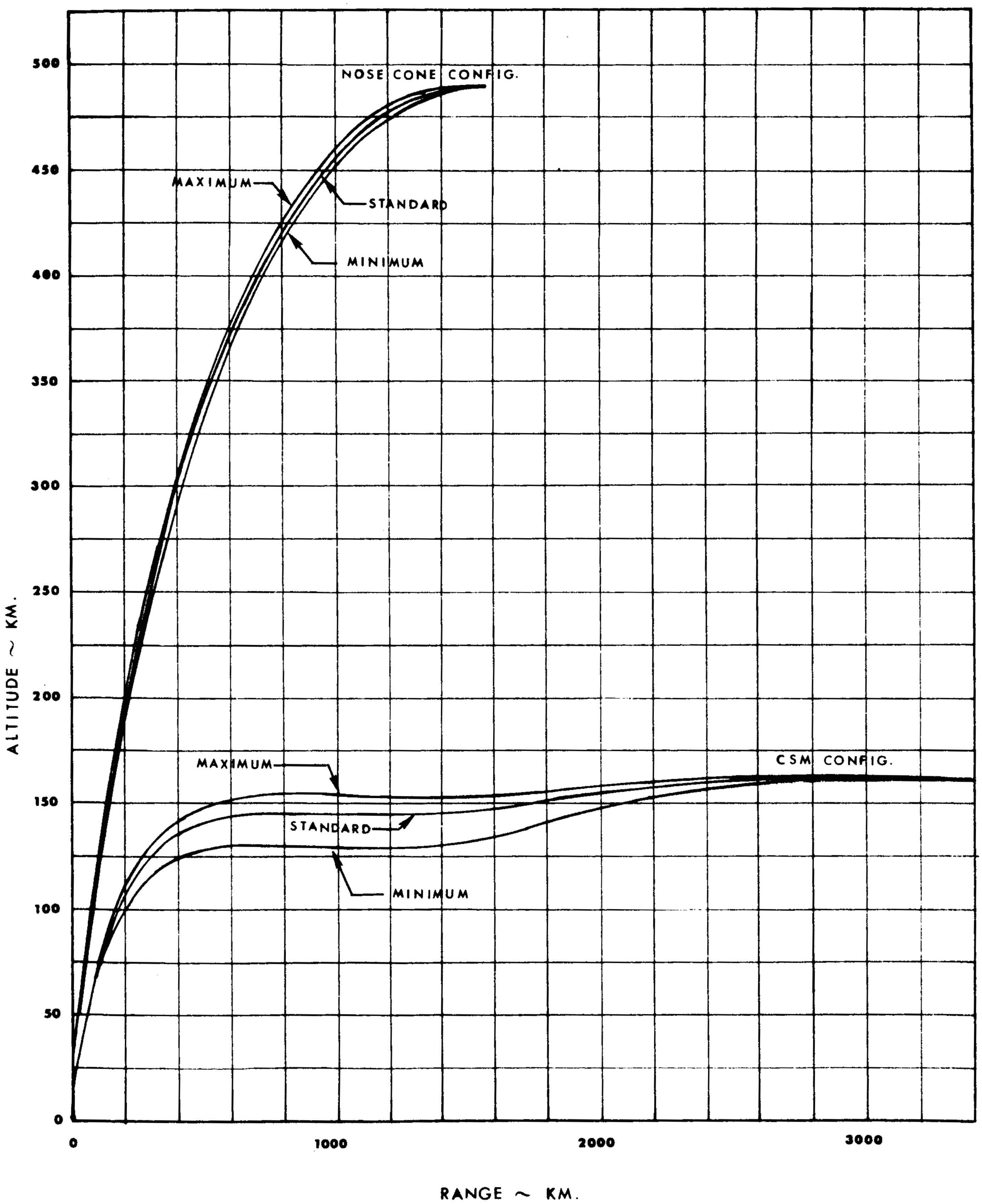


Fig. 4

scb

NOSE CONE AND CSM INSTANTANEOUS IMPACT TRACE

ASCENT TRAJECTORY

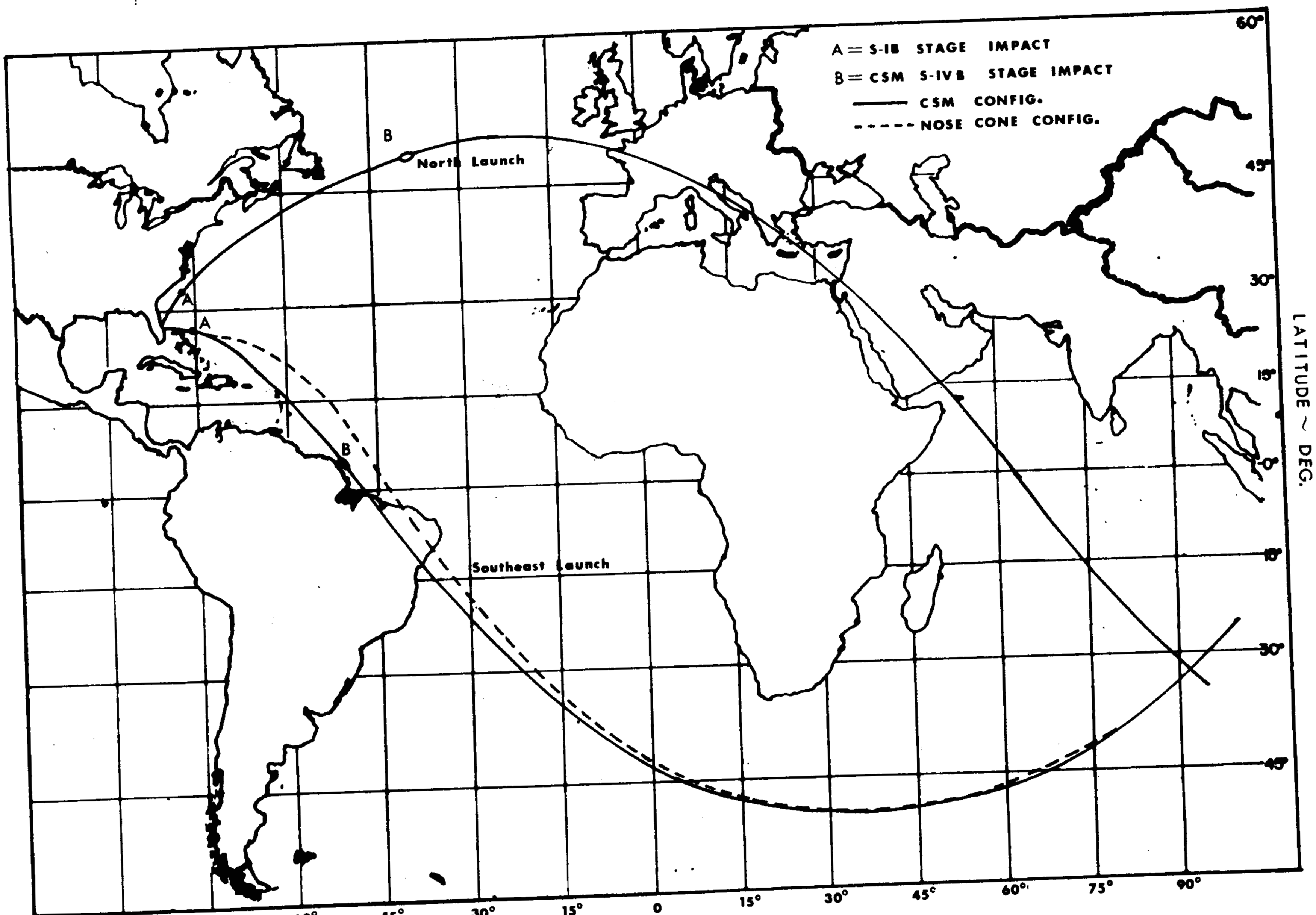
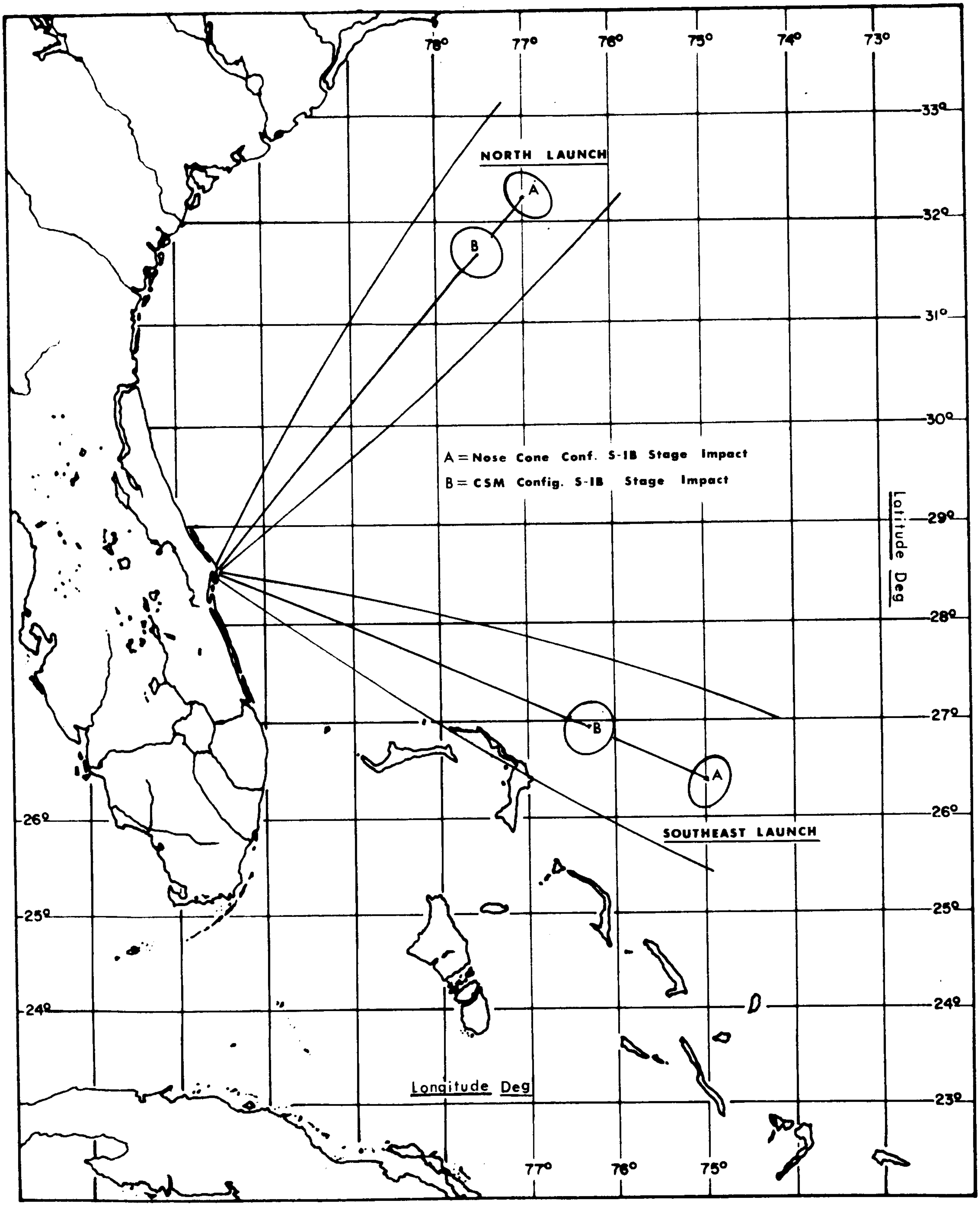


Fig. 5

Fig. 6



NOSE CONE AND CSM INSTANTANEOUS IMPACT TRACE

AND CROSSRANGE CORRIDOR - S-IB STAGE

scb

NOSE CONE AND CSM INSTANTANEOUS IMPACT TRACE AND CROSSRANGE CORRIDOR - EURASIA

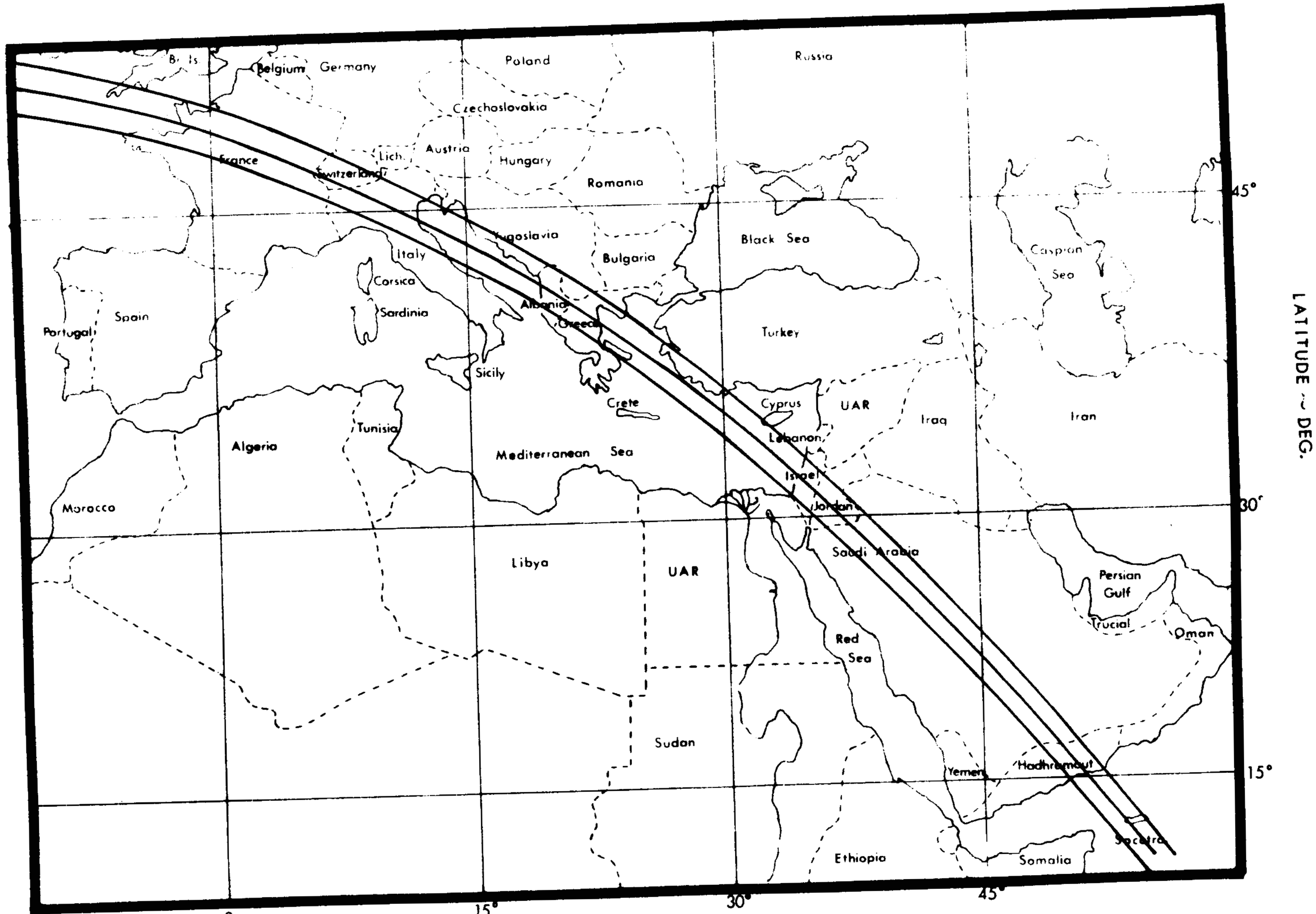
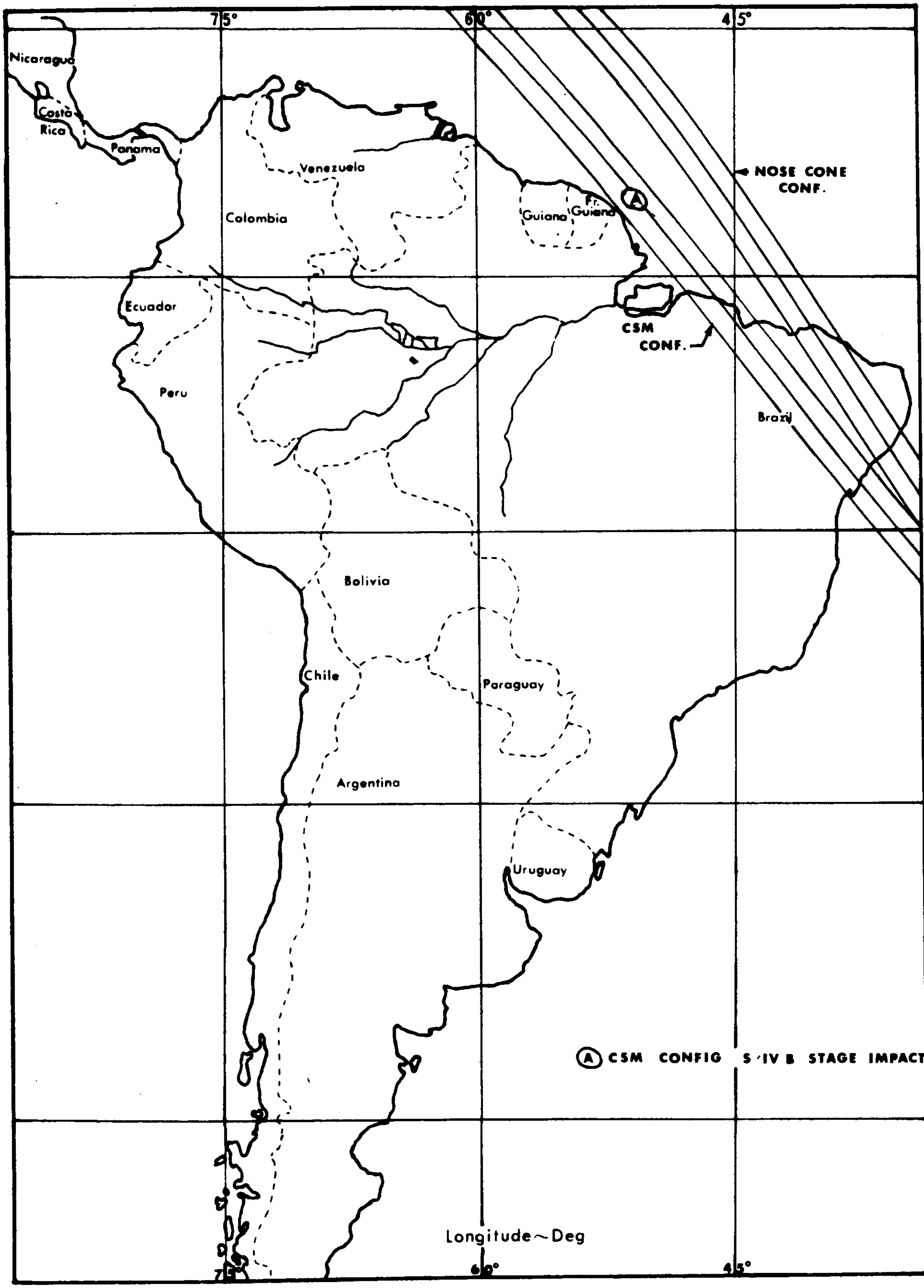


Fig. 7



NOSE CONE AND CSM INSTANTANEOUS IMPACT TRACE AND CROSSRANGE CORRIDOR - SOUTH AMERICA

FIG. 8